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(Continued from April number)

PRESIDENT FORBES: If there is no further discussion, the next paper will be "Notes of the Year from North Carolina," by Mr. Sherman.

NOTES OF THE YEAR (1908) FROM NORTH CAROLINA

By FRANKLIN SHERMAN, JR., *Raleigh, N. C.*

While the great majority of the complaints that have reached my office during the year just closing have been of species already widely known, yet there have been a number that have, in some way, more than usual interest.

In March a complaint (with specimens) was received from Wilmington, in the southeastern part of the state, of a species of "mite" or "flea," which was proving very troublesome by burrowing into the skins of persons. They were reported as being very abundant all over the ground, under the house, in the stables, and in chicken-coops. Specimens were at once forwarded to Prof. Herbert Osborn of the Ohio State University, who identified it as the Chicken Flea (*Xestopsylla (Sarcopsylla) gallinacea*), which he says has been troublesome in Florida and Texas for a number of years, but which had not previously been recorded north of South Carolina. Evidently this creature is extending its range and may eventually inhabit all the warm sandy coast districts. This flea was discussed in the December

issue of the JOURNAL OF ECONOMIC ENTOMOLOGY, in an article by Professor Herrick.

The Strawberry Weevil (*Anthonomus signatus*) again did serious damage in the spring in the southeastern part of our state, where the strawberry is an important crop. A number of years ago we demonstrated at least the *futility* of a number of supposed remedies, and as the favorite varieties of early berries are principally pollen-bearing sorts, growers do not take readily to the suggestion to use pistillate varieties.

The Cabbage Louse (*Aphis brassicae*) is a serious pest with us almost every spring. The insect seems to pass the winter in all stages, in small (or large) colonies on the leaves of fall-set cabbage, or on winter collards (a cruciferous crop peculiar to the south) and multiply abundantly when warm spring weather comes. We have found that complicated emulsions of kerosene, with the necessary care as to exact proportions of oil and water, are not at all necessary. Any ordinarily strong laundry soap shaved in thin pieces and dissolved in boiling water and then diluted to 1 pound of soap to 3 gallons of water is an entirely satisfactory remedy. One grower even wrote me that water filtered through a barrel of wood ashes extracted enough lye so that it was effectual, but I am not able to positively confirm this.

And right here let me say a word for simplicity. The average farmer, trucker, or fruit-grower (at least in North Carolina) is not disposed to prepare and use remedies in which special care has to be used to get proportions exact and where there are also many ingredients. We need to remember that an entomologist in the zeal of his experiment can easily procure all sorts of substances, and use methods of exactness, which the ordinary farmer will not, and in most cases cannot, use. We blissfully recommend "kerosene emulsion at the strength of 25% oil" for this, or "at rate of 15% oil" for that, and yet we must know that not one man in a dozen to whom we make these suggestions actually goes to the trouble of preparing the emulsion and testing the advice. In this I believe that my experience is not different from that of other entomologists. The simpler the process of preparing a remedy, the fewer the ingredients, and the easier they may be obtained the better, even though it may kill a less percentage of the offending insects.

In the latter part of March I received complaint of a species of "little brown cricket," which, to quote from my correspondent:

"Piles up dirt at his hole like an ant, and promises to give a lot of trouble with tobacco and other plants that are transplanted. They cut the plants off and pull them in the ground. I see that they are

..re plentiful than I ever saw them before in land that I want to ..ant in tobacco. I have some cabbage that they are cutting off now."

A later letter from the same party said that "they live deep in ..e clay and come out at night to do their destruction."

Upon securing specimens it was found that the culprit was the cricket *Anurogryllus muticus*, of which we had never before had complaint and which was only meagerly represented in our collections. The burrowing habit of the species is discussed by Rev. A. H. Manee (of Southern Pines, N. C.) in the December issue of *Entomological News*.

From time to time ever since I have been in North Carolina I have heard vague reports of a "Root-louse" or "Blue-bug" which was said to attack roots of cotton. The reports always indicated that it was a serious pest, but they always reached me at such times or in such manner that no specimens were available. Only the persistency of the reports kept me from assigning them to the scrap-pile of entomological fallacies. The year 1907 brought out an unusual crop of reports, but in no case could I get specimens. I determined, however, to lay plans for at least determining the identity of the pest in 1908, and, accordingly, last spring sent out a circular letter to numerous growers saying that even the identity of the insect was yet in doubt and asking their aid in ferreting out the culprit. As a consequence we definitely determined that the species concerned is *Aphis maidi-radicis* Forbes, famous as the Corn Root-aphis of the Central States. We found, too, that in the cotton-fields of North Carolina it is commonly attended by the ant *Lasius aliena* Forst, which is considered to be a variety of *Lasius niger*, the common ant in attendance on the Corn Root-aphis in Illinois.

Aphis maidi-radicis has not heretofore been recognized as a cotton pest. Dr. Howard wrote me that it had been once reported from South Carolina on cotton,--but no published account of it had appeared. Yet I am convinced that it is (at least in North Carolina) a cotton pest of real importance and of wide distribution. I found it in cotton fields at Raleigh where the infested plants were invariably more stunted and belated in their growth than uninfested ones nearby. Growers say that these stunted plants are likely to be caught by frost before they can mature their crop.

This insect has never been reported to me as a corn pest until the past spring when one complaint was received from a section where the Cotton Root-louse is not complained of. I cannot take time and space here to discuss further the abundance and destructiveness of the pest as revealed by my correspondents, but I have scarcely a doubt

that in eastern North Carolina it is a pest of long standing, and is one of the three or four most important insect enemies of the Cotton Crop,—perhaps the most important of all.

A beetle of the family *Chrysomelidæ*, by the name of *Luperodes brunneus*, has been given the title of "The New Cotton Beetle" by Prof. R. I. Smith, in Bulletin 20 of the Georgia State Board of Entomology. The species was reported from Georgia as a pest of cotton as early as 1892, and in 1905 was sufficiently destructive to cause its discussion in the Bulletin referred to. This same beetle did similar injury with us in 1903, 1904 and 1905,—and in the present year (1908) it was sent to me with the complaint that it was doing destruction to corn by eating the silk off clean down to the husk, and devouring the pollen from the tassels. It seems to have preference for the young flowering portions of the plants which it attacks.

The Cotton Boll-weevil, while of course far from our borders at the present time, is alleged to have appeared from time to time. About 15 distinct species of insects have been sent in on suspicion of being Boll-weevil, these proving to be everything from the species of nut-weevils (*Balaninus*) to Boll-worm and adult Lace-wing flies. The campaign of education is beginning to tell, however, and each year a larger and larger proportion of the insects sent in are of the sub-order Rhyncophora, which shows that some discrimination is being used in the complaints and inquiries.

The genuine northern Army-worm (*Heliophila unipuncta*) cropped out in destructive numbers in August not far from Raleigh where it was not thought that it would normally be destructive, although the adults occur in the fall every year. The outbreak was looked into by my assistant, Mr. Z. P. Metcalf, and the interesting studies which he made on the parasitism of the species by its usual Tachinid parasite, are recorded in the December issue of the JOURNAL OF ECONOMIC ENTOMOLOGY.

The Gloomy Scale (*Aspidiotus tenebricosus*) is a pest with us on certain varieties of maple, and more than the usual number of complaints have been recorded in 1908. Studies made by Mr. Metcalf show that it is confined principally, if not entirely, to the varieties known as Red Maple and Silver Maple, while the Sugar Maple, which is the one chiefly relied on for shade in Raleigh, is not attacked.

The Elm Beetle (*Galerucella luteola*) is destructive with us every year, chiefly in the towns in the piedmont or red-clay region between the elevations of 500 and 1,000 feet. As nearly as I can ascertain the injury began to be truly serious about 1898, but the insect is now destructive in most of our larger towns in the part of the state referred to.

Finally, I would refer briefly to a work which we only began this year in definite manner. Last year at Chicago Dr. Fernald referred to the fact that despite the efforts of the entomologists, the ravages by insects continues to increase, and called our attention to the fact,—only too painfully apparent to us all,—that only a small number of our constituents really carry our recommendations into practice.

It does seem to me that we have slipped a cog somewhere when, at this late day, we still have in every state hundreds of men who depend on apple orchards for a part of their income, and who not only do not spray, but do not believe that spraying of apples will actually pay for itself in average years! These doubters are in the majority in some of our states and I believe that we owe fully as much to the duty of *proving the facts* to these men, as to discovering newer facts and principles for the more progressive minority of our people.

During 1908 we conducted apple spraying demonstrations in six different counties in North Carolina, at one place in each county. In each case three sprayings were given, the first treatment being made the occasion of a public meeting,—a sort of field institute which was advertised throughout the county through the regular Farmers' Institute organizations. A complete barrel outfit with two leads of hose, and also a complete bucket outfit were shipped from place to place. Bordeaux Mixture and Paris Green were prepared before the audience at each place, and the spraying was done before their eyes. Three trees only were used in each test, and one of them was sprayed only on one side.

We requested a report from the owners in July to show the condition at midsummer, and again in October to show the condition at apple harvest. No effort was made to work out exact details as to percentage of wormy fruit, etc. All we wanted was to demonstrate the matter to the fruit-grower from his own everyday standpoint, and this we did. Mr. S. C. Clapp, inspector of orchards for my office, did much of this work, and he visited some of the places during the summer and said the difference between the treated and untreated trees was remarkable. The five mid-summer reports were all enthusiastic, and the five autumn reports were even more so. I have recently sent out a circular to an especially prepared list of fruit-growers of our state, describing this work and giving all these reports. If this kind of demonstration work does not take a real hold among our growers and convince them of the real value of a spray pump, I shall be disappointed.

This kind of work cannot be called research and the strictly guarded Adams' fund cannot be used for it. But I submit that while we ought

to continue to seek for new facts and new principles in our science, we must strive no less to bring the already well-known and well-established facts into the common every-day practice of a much greater number of our people.

President Forbes: As there are two other papers on the list of a similar character, I think we will postpone discussion until after they have been presented. The next paper will be "Entomological Notes from Georgia," by Mr. Worsham.

INSECTS OF THE YEAR IN GEORGIA

By E. L. Worsham, *State Entomologist*

This year, as in the past, the board has devoted most of its time to apple, peach, field and garden insects. The insects infesting the peach and apple have been the most important, and much attention has been devoted to these insects. Several new insects have been reported for the first time, as doing considerable damage. The insects which stand at the head of the list from standpoint of damage done are the various scale insects.

The San José scale (*Aspidiotus perniciosus*) is the most important insect with which we have to deal, though it may be said that it is not feared now nearly so much as it was a few years ago. Its spread over the state is very slow on account of the rigid nursery and orchard inspection maintained by the State Board of Entomology. The lime-sulfur wash is still the leading spray for this scale. In orchards where this wash has been used for four or five years the scale has been greatly reduced and the condition of the orchards much improved. For the past two years the board has conducted experiments with a number of miscible oils. Some gave very good results, but it is yet too early to say how they will succeed in the commercial orchards.

The Cherry Scale (*Aspidiotus forbesi*) has been found quite numerous in some cases, though as a rule it does not do a great deal of damage.

Peach Lecanium (*Eulecanium nigrofasciatum*) has been found in a number of orchards where spraying with lime-sulfur wash was not practised last season.

The Oyster Shell Bark Louse (*Mytilaspis pomorum*) and the Scurvy Bark Louse (*Chionaspis furfura*) were found in a few orchards and on some trees they were quite numerous. The latter was found for the first time on peach trees at Waynesboro.

The West Indian Peach Scale (*Diaspis pentagona*) was found to be quite abundant in Augusta. It was found on peach, catalpa and mulberry trees, having almost killed the peach and literally covering the mulberry trees. It was found on almost all of the mulberry trees in the lower part of the city. Steps will be taken this winter to exterminate it before it spreads into the peach orchards. It was thought last season that this scale did not exist in the state, as a search was made where it was present a few years ago, and none found. Just how and when it was introduced into Augusta is not known.

In addition to the above, the following scale insects have been found: *Aspidiotus tenebricosus,* on poplar trees, Augusta, Ga.; *Ceroplastes cirripediformis,* on hackberry trees, Augusta; and a species of *Kermes* quite common on oaks in many parts of the state.

The Gloomy Scale (*Aspidiotus obscurus*) is very common on oaks and maples. In some cases it is being kept down by the red headed fungus, but maple trees in Atlanta are being killed by this scale.

Euonymus scale (*Chionaspis euonymi*) did considerable damage during 1908, killing several hedges in Atlanta and elsewhere.

The White Fly (*Aleyrodes citri*) was more numerous during the summer than ever before. In South Georgia it was quite common on orange, California privet, umbrella trees and cape jessamine. At Darien it did some damage to the sweet and sour oranges. We have no record of any remedial measures that have thus far been tried.

The Shot-hole Borer (*Scolytus rugulosus*) was quite common this last summer, and, as in 1905, was found in some cases to attack trees that, to all appearance, were perfectly sound. At Woodbury Mr. Betts had some badly infested trees, which he saved by painting the trunks and limbs with lime-sulfur wash.

The Peach Tree Borer (*Sanninoidea exitiosa*) is still a great pest in Georgia. When mounding and worming, together with the application of a caustic wash, is practised, it does but little damage, but in neglected orchards it injures many trees. This insect is better controlled than it was a few years ago, as many have learned by dear experience that the applications of repellent washes are not effective.

Numerous orchards last fall showed the work of the Peach Twig Borer (*Anarsia lineatella*), and in some cases they seemed to be doing considerable damage. In old neglected orchards they are most common. In orchards where the lime-sulfur wash is used they do little damage.

The Plum Curculio (*Conotrachelus nenuphar*) was not so abundant as in previous years. A few orchards showed bad infestation. In one peach orchard near Woodbury it destroyed about 50% of the

peaches. This orchard had not been ploughed for two years. A few large commercial orchards were sprayed this last spring for curculio, as our experiments in 1907 gave fairly good results. In these experiments we used two pounds of arsenate of lead and three pounds of lime to fifty gallons of water. Where we sprayed twice, 69% of the fruit was sound; three times, 72% of the fruit was sound, and where we sprayed four times, 75% of the fruit was sound. On unsprayed trees there were 13 to 49% of sound fruit; or on seven unsprayed trees a general average of 30% sound. In the orchards where experiments were conducted this year there was scarcely any curculio present so we obtained no results. From the work carried on for the last three years, we have decided it is not safe to spray peaches more than twice after blooming, on account of injury to the foliage and fruit.

The Codling Moth (*Carpocapsa pomonella*) was quite abundant in unsprayed orchards. We have been conducting spraying experiments for control of this insect for the past three years, and the results will soon be published in detail, so we will only mention the work briefly. It now seems that the number of broods varies each year. In 1906 two broods and a part of a third brood were found; in 1907 nearly three complete broods; in 1908 three full and a part of a fourth brood. But it must be remembered that this was an extremely early spring, fruit blooming about ten days earlier than usual, so the Codling Moth has had a long season in which to develop.

In controlling the Codling Moth the best results were secured by spraying, once before the calyx closed, and twice for the second brood. However, very nearly as good results were secured by spraying once before the calyx closed and once for the second brood. One spraying before the calyx closed gave as good results as three sprayings applied: first, as petals fell; second, before the calyx closed; and third, ten days later. In all of these sprayings we used Disparene, two pounds; bluestone, three pounds; lime, six pounds; water, fifty gallons.

The Woolly Aphis of the apple (*Schizoneura lanigera*) was present, as usual, in many apple orchards. Some growers are now using the kerosene emulsion for this insect with very good results.

The Green-apple Aphis (*Aphis pomi*) was quite abundant in a few orchards. We are now advising the use of the tobacco decoction, or 15% kerosene emulsion for fighting this louse. To beginners in spraying we usually recommend the tobacco decoction as being the least likely to injure the trees.

The Hessian Fly (*Mayetiola destructor*) was present in many wheat

fields, but the infestation as a rule was light and no great amount of damage was done. The board has been working on this insect for several years, and in September a circular was issued giving the results thus far secured. From this study it has been found that if wheat is sown from October 20th to 30th, it will not as a rule be damaged to any great extent by the fly.

The Boll Worm (*Heliothis obsoleta*) was present in many cotton fields, but no great amount of damage reported.

The New Cotton Beetle (*Luperodes brunneus*) appeared again in June, as it did last year. The first week in July Mr. A. C. Lewis examined some fields where they had been and found that the damage in no case was very great. The beetles first appeared about June 20th, and by July 1st had disappeared. So far, we have had no chance to try poison against this insect.

The Red Spider (*Tetranychus gloveri*) was present, as it is nearly every year, in several sections of the state. In a field of ten acres near Midville it did considerable damage, and in several other sections of the state great damage was reported. For this insect we recommend dusting with sulfur. Several cotton growers dusted with sulfur and with sulfur and slaked lime, with excellent results.

Specimens of the Striped Cucumber Beetle (*Diabrotica vittata*), the common potato beetle (*Doryphora 10-lineata*), and specimens of Harlequin Cabbage Bug (*Murgantia histrionica*) were frequently received by mail during summer. During summer and early fall we received letters from several parties in South Georgia stating that the mole cricket (*Scapteriscus didactylus*) was doing a great deal of damage to garden crops. Near Darien one party was using poisoned bran mash to kill these crickets, with fairly good results.

Several times during the summer letters were received from South Georgia stating that a worm was killing cow-peas. The worms ate out the heart of the stem at, or just below, the ground. In one field near Quitman two or three acres were almost completely destroyed. When we visited the fields which they had infested we found that they had disappeared and a careful inspection showed that they had gone into the ground and were found about two or three inches below the surface. It is a lepidopterous larva, but as yet we have not succeeded in getting adults to emerge.

During the summer and early fall much damage was reported from Cabbage Web Worm. A number of truck farmers in South Georgia state that it is impossible to grow cabbage, turnips and other such plants on account of this insect. Remedial measures have not been very successful.

President Forbes: The third paper of the series is "Insects of the Year in Iowa," by Mr. R. L. Webster.

INSECTS OF THE YEAR IN IOWA

By R. L. Webster, *Ames, Iowa*

The following notes on insect injuries in Iowa during the past year are taken from office correspondence of Prof. H. E. Summers and from observations of the writer.

The English grain louse, *Macrosiphum granaria*, which was so common in Iowa and Minnesota last year, has been hardly noticeable during the past season. Early in the spring it looked as if this species might again threaten the wheat and oat crop, as it did last year. Winged forms of *Macrosiphum granaria* appeared in plots of winter wheat at Ames on April 11th. Just where these winged forms came from is unknown. Certainly they did not come from the young nymphs on the wheat, for only the very young progeny of the winged forms themselves were found. Had the species spent the winter on the grain there should have been some pupæ or older nymphs present. Moreover, the plots had been examined almost daily for several weeks preceding and no traces of aphids of any species had been found. The wind had been in the south for two or three days previous, so it is possible that the insect had been blown in. Were the time later in the spring, a migration from one food plant to another would be probable, but at this time of the season I do not know from what plant the aphid would migrate. Last year I found the winged forms of this species at Albert Lea, Minnesota, May 20th, the first appearance of the insect in any form in Minnesota that spring. These winged forms had also apparently only recently reached the grain from some other situation.

The spring grain aphis, or green bug, *Toxoptera graminum*, was also scarce in Iowa this year. Not until July 8th were any specimens found, at which time some apterous forms appeared on volunteer oats. These were found along the right of way of the C. & N. W. Railway, west of Ames. What was probably the same species was found at Council Bluffs on August 6th, but nowhere else in the state. Neither this nor the preceding species were found in southern Iowa in March, when a thorough search was made for them in fields of winter wheat.

The wheat head army worm, *Heliophila albilinea*, was very common over the state during July, especially upon timothy. The stalk borer, *Papaipema nitela*, was also common during the summer, boring in corn and oats. The clover seed caterpillar, *Enarmonia in-*

...inctana, has been in clover fields in the vicinity of Ames. A rather uncommon plant louse, *Aphis bakeri* Cowen, has been extremely common in clover fields around Ames, causing some serious injury. One field near the college was severely attacked by this aphis. In midsummer the aphids were found on the heads and stems of the plants, but as the weather became colder they moved to the lower parts of the stems, where they were found late in the fall, attended by the large black ant, *Formica fusca*. The aphis was identified for me by Mr. J. J. Davis from specimens found on the stems of clover at Ames.

A strawberry root worm, *Graphops nebulosus* Lec., was reported from the eastern part of the state as causing serious injury to strawberry plants. This is the first time that this species has been noted as being injurious in this stage.

The woolly aphis, *Schizoneura lanigera*, has not been so common in the nurseries of the state as in previous years. It could scarcely be found during the season in nurseries which have had much trouble with this insect. Towards the latter part of July the apple-aphis, *Aphis mali*, became very numerous on apple stock in nurseries, as well as on young apple trees in orchards.

The apple leaf hopper, *Empoasca mali*, continues to be abundant in nurseries generally. In one large nursery at Charles City, in the northern part of the state, the apple stock was again attacked by this little hopper. From some observations made during the summer in various parts of the state, there appears to be five broods of the hoppers during the season, the young hoppers appearing about once a month, from May to September. The lesser apple leaf-folder, *Acleris minuta*, caused serious injury to apple stock in two large nurseries in the southwestern part of the state. A series of spraying experiments showed that this insect may be successfully controlled by spraying with arsenate of lead, the spraying being done when the insect was still in the egg stage. Spraying after the larvæ were old enough to fold entire leaves was of no practical value.

Chionaspis pinifoliae was noticed to be fairly common among evergreens in one of the large nurseries in southwestern Iowa, but did no appreciable damage. Black Hills spruce and Scotch pine were the varieties most affected. A much more serious pest, the San José scale, made its appearance in Iowa during the past year. This outbreak is treated more fully by Professor Summers in a separate article to be given at this meeting.

A cherry slug, presumably *Eriocampoides limacina*, stripped many cherry trees of their leaves in the town of Ames and vicinity. The second brood of this insect was especially numerous. Early in the

season the box elder aphis, *Chaitophorus negundinis,* was very common on the box elder trees in various parts of the state. The Buffalo tree-hopper, *Ceresa bubalus,* continues to be abundant on young apple trees in orchards, causing serious losses to young apple trees every year. One orchard of fifty acres of young apple trees at West Branch, Iowa, was severely injured by the work of this insect. Clean culture in the orchards is advised against this pest.

PRESIDENT FORBES: These three papers are now open for discussion.

MR. WASHBURN: The paper by Mr. Webster interests me because he deals with insects that we have in Minnesota. We have not been able to find the fall eggs of *Macrosiphum granaria* so far. Last year Mr. Vickery found females producing young under snow, about the tenth of December, and this year we have found the same thing. And in the insectary, where the themometer had been down to five below zero, on the same date, December 10, we found the same condition, but no eggs. We have not been able so far to find any winter eggs. We find eggs of *Toxoptera* and the question arises, is *T. graminum* really a visitor from the south?. We find it away up to the northern border, and the fact that the eggs survive the winter and hatch in the spring would seem to indicate that it is with us all the time.

MR. R. L. WEBSTER: I found only the winged forms of *Macrosiphum granaria* early in the year in Iowa and Minnesota. In what form did you find it first this spring?

MR. WASHBURN: I believe they were winged forms.

MR. COOLEY: Mr. President, I have an idea that there will be found an alternation of generations in *Macrosiphum.*

MR. KELLY: I think that Mr. Cooley has undoubtedly found the eggs of *Macrosiphum* at Bozeman, Montana.

MR. SANDERSON: We got the eggs in May or June in Texas, in the laboratory, from two or three different lots, but we never could find any trace of them in the field.

MR. SLINGERLAND: I was interested in the application and mixing of kerosene emulsion. I have a few stunts that I put the boys through in the practical mixing of insecticides, and you would be surprised at the arithmetic they sometimes use in making up kerosene emulsion. I believe it is very important for them to realize the necessity for accuracy in mixing kerosene emulsion.

MR. SHERMAN: If the college student has all that trouble, how

about the actual farmers, nine tenths of whom have never been to college or high school? I make a plea right here for an easy formula that any farmer can understand and use without trouble. All these complications I am inclined to think we can do away with to a large extent, and I do make a plea for simplicity in these things.

MR. J. B. SMITH: I want to express my agreement with what Mr. Sherman has said. It is the basis of my recommendations for commercial insecticides in most cases. Most farmers would pay a little more for a commercial insecticide than to make it up themselves. It was for this reason that I urged, some years ago, upon manufacturers the preparation of an oil that would be directly soluble in water. It was for that reason that I urged manufacturers of chemicals and manufacturing chemists to attempt the preparation of a commercial lime sulfur mixture. It is for that reason that another manufacturer is attempting and has actually manufactured a soluble sulfur, that is, a preparation of sulfur in the liquid form that dissolves by simply putting it in water, without any combination with lime. It is the manufacturer of chemicals that will help the entomologist out if he is given a chance, and I recommend the manufacture of commercial insecticides, and I recommend that the farmer buy his insecticides instead of trying to make them himself, for he will certainly make a botch of it if he possibly can do it.

MR. SLINGERLAND: Mr. President, I feel there is a bit of danger in some of Professor Sherman's notions, especially in regard to the methods of conducting demonstration experiments. I am a firm believer in such experiments, but can we not carry on these demonstration experiments scientifically just as easily? If a farmer sees you do it a bit slovenly, he will often go to the other extreme and do it very carelessly and thus get unsatisfactory results.

A MEMBER: Mr. President, it seems to me that kerosene emulsion has been given a rather bad reputation here in this discussion. I want to come to the rescue of kerosene emulsion as a simple insecticide. It is true that a great many orchard men fail in mixing it up, but I believe there is a chance for the elevation of the standard of our orchard men, so as to make them able to prepare kerosene emulsion and make no mistake. I have seen orchardists in one season, in one county, prepare, of their own accord largely, about 500,000 gallons of kerosene emulsion and use it successfully against woolly aphis, and I want to say that kerosene emulsion against woolly aphis, with its powers of penetration, is a splendid insecticide.

MR. SHERMAN: I maintain that the majority of the people in North

Carolina and every other state will not use these complicated mixtures if they can get anything simpler.

MR. BRITTON: Mr. President, I have been much interested in this matter and about the method of getting information before the farmers who need it. In many cases our bulletins are large and are sent to certain names on the mailing list. They may reach the farmer, but he may be too busy to read them. I wish to call your attention to a simple method which has been used by us for a few years, of getting a very brief notice quickly before the farmers. We call it the "Postal Card Bulletin." It is four by seven inches in size and is made of the same stock as the ordinary postal card. The franks and address can be stamped on the face and on the back is printed very briefly the instructions that we wish to place before the farmer. In receiving this short notice he is more likely to read it and this card is especially well adapted to information of a timely nature. We don't claim any originality for it, though we have not seen anything like it elsewhere.

After transacting the usual routine business, which has already been reported, the meeting adjourned.

A. F. BURGESS, *Secretary.*

The following papers were read by title and are herewith printed in full:

OUTLINE OF AN INVESTIGATION INTO THE USE OF HYDROCYANIC ACID AND CARBON DI-SULFID GASES AS FUMIGANTS

By W. E. HINDS, *Auburn, Ala.*

The second object as stated in the constitution of this Association is "To give opportunity to individual workers of announcing proposed investigations so as to bring out suggestions and prevent unnecessary duplication of work." Although this has long been one of the primary objects in the meetings of the Association, the records show that comparatively little has been presented at the meetings along this line. The writer believes that we may very profitably discuss proposed work in these meetings, and his principal objects in presenting the present paper are three in number. First, to announce the general plan of the investigation which is now under way; second, to give occasion for a general discussion of methods, plans and objects presented, with a view of securing suggestions as to valuable experimental work which has been done by others and as to changes in present plans which may appear advisable; and third, to get an expres-

sion of the views of other workers as to the most important problems existing in this particular field of investigation.

The paper will therefore be confined to a general discussion of the project, leaving out entirely the question of results which have already been obtained. For a general understanding of the project, its subject and objects may be stated as outlined in the writer's plan of work.

Subject.—An investigation of the factors governing the production, diffusion and insecticidal efficiency of hydrocyanic acid gas and carbon di-sulfid vapor as used in economic entomology.

Object.—1. To establish a scientific basis for practical working requirements under known conditions. 2. Determination of minimum effective time and dosage required by various insect species. 3. Determination of maximum safe time and dosage usable with various plants. 4. Standardization of effective and economical formulæ for various needs. 5. Determining modifications required for effective work under varying conditions of temperature, moisture, light, insect protection and plant resistance.

Need for this Investigation.—From many points of view it would seem that this is one of the most important general fields of investigation demanding immediate attention by the economic entomologists. The general requirement for the fumigation of nursery stock before its sale and distribution has led to considerable experimental work in the use of hydrocyanic acid gas. The results obtained are in many instances indefinite, doubtful, or even contradictory, and as a rule the experimental work has been done under such conditions that no reasonable explanation of these inconsistencies can be given. The commercial value of the stock thus treated must amount to many millions of dollars annually. The cost of treatment, while small as compared with the value of the stock itself, is still a large item in the aggregate.

Besides its use for treatment of nursery stock while in a dormant condition, hydrocyanic acid gas is coming to be extensively used for the treatment of citrus trees and green house crops, involving its application to living plants which may be in an active growing condition. The reasons for susceptibility of various plants to injury by gas treatment are but vaguely understood, while their importance as bearing upon the general adoption of fumigation methods in green house and orchard work is very great.

The loss occasioned by insects to stored cereals and their products was estimated by Mr. Marlatt for 1904 as being over 100 million dollars. These losses are particularly severe with corn and various

leguminous seeds. At the present time comparatively little is being done to prevent this enormous loss. If we consider also the damage to such products in retail establishments, to household goods, tobacco products, etc., and consider also that the total crop valuation for 1908 is approximately eight billion dollars as compared with five billions for 1904, it would appear that the total insect damage for which treatment might be made by fumigation will in the three classes of nursery stock, green house crops and storage products probably amount to between 200 and 300 millions of dollars annually.

In spite of the enormous economic importance of these fumigants in insecticidal work, we must admit frankly that our use of them is very largely based upon guess work, which only too frequently results in (1) lack of insecticidal efficiency, (2) more or less injury to the plants or materials treated, (3) to unnecessary expense involved in the waste of materials and frequently also in the time given to the treatment. In case the treatment given is too weak to kill the insects for which it is applied, all of the materials and time must be considered as wasted, and similarly there is a waste in the use of a large excess above what is actually needed to kill the pests.

Even with hydrocyanic acid gas, which has been used experimentally much more than has Carbon di-sulfid, it is evident that there is a great variation in the dosage advised by different entomologists for the same purpose. No reasons for such variations are given, and only too frequently the results obtained are such as to discredit the reliability of entomological recommendations.

Particularly in regard to the use of Carbon di-sulfid it is noticeable that the great majority of recommendations are mere repetitions of what some other man has previously advised. So far as we have been able to learn, very few definite investigational experiments have been attempted with this fumigant, and unquestionably the recommendation which is generally given cannot be relied upon to accomplish the desired result.

It seems therefore that the field open to investigation is exceedingly broad and sufficiently important to command the most careful investigation possible.

Scope of Work Contemplated.—In a general way we propose to cover a fair range of subjects in the field outlined above. To learn for each fumigant under different working conditions the general limits of minimum dosage necessary to effect the destruction of various insect pests, the maximum treatment endurable by various living plants, both in green houses and out of doors; and for nursery stock, to determine the modifying influences of such obvious factors as light.

temperature, humidity, etc., and to test other factors which may seem important. The treatment of seeds intended for germination is another important phase of the work, both as regards the prevention of insect injury to the seed and the possibility of preventing this without injuring, by the treatment, the germinating power.

It will be seen from the preceding statements that the work contemplated involves more than the usual field of economic entomology, particularly in the determination of the maximum endurable time and dosage usable with various plants and in the modifications required for effective work under varying conditions of temperature, moisture, light, etc. The project involves much work in anatomical and physiological botany.

Co-operation.—Arrangements have already been made for coöperation in this botanical part of the investigation. Prof. F. E. Lloyd, whose investigations regarding the "Physiology of Stomata" have been recently published in Carnegie Institution Bulletin No. 82, has been recently appointed professor of botany and botanist to the Experiment Station of the Alabama Polytechnic Institute. His experience in this field of investigation seems to fit him in an exceptional way for this portion of the work. He will therefore undertake, in coöperation with the Department of Entomology, the investigation of the anatomical and physiological reactions of various plant tissues to these two fumigants, especially with regard to the effects upon their nutritive and respiratory functions. He will also investigate the general question of the susceptibility or resistance of common green house and other plants frequently liable to such treatment, to the effects of these gases under various conditions of treatment so as to determine, if possible, the general conditions under which fumigation for insect pests may be practised with the greatest possible safety to living plants. The ultimate object will be to establish a basis for making intelligently such necessary or desirable modifications as are demanded for successful fumigation work under varying practical conditions, so that the destruction of insect pests may be assured without endangering the life of the plant and without involving needless expense in time and materials for making the treatment.

Methods of Procedure.—The following general principles will be observed whenever possible in securing the data upon which the conclusions may be based:

1. Chemical analysis of samples of materials used in tests.
2. Establishing definitely known working conditions.
3. Securing data from experiments in which, so far as may be possible, only one factor at a time will be varied.

4. Selection of subjects to secure uniformity and to render results comparable.

5. Determination and study of the influence of important modifying factors.

6. Immediate classification of the data.

7. Statements of general results and conclusions indicated by work done and determination of their bearing upon the establishment of general principles for practical work.

In a general way the method of procedure adopted is to secure preliminary indications of results by conducting series of small tests under controllable laboratory conditions. E. g., for this work two-liter bell jars are used and the work with insects and seeds begins under the constant condition of a practically uniform strength of gas acting through a graduated series of time intervals. In this way one factor at a time will be varied until ultimately the usual, general effect of each may be established.

When these small tests have indicated some general result, tests will be made using fairly large quantities of material to determine the constancy of the results obtained. The general applicability of methods of treatment to usual conditions under which treatment may be required will then be investigated. Thus laboratory results will be checked by practical application under the conditions for which treatment might be advised.

In conclusion I may say for those conducting this investigation that we shall cordially welcome at all times criticisms showing any avoidable points of weakness in our work. We shall be glad of any suggestions as to improved methods for securing the information we need and we are especially desirous of securing the benefit of the viewpoint of others regarding the importance of various problems which may properly come within the scope of this investigation.

ENTOMOLOGICAL NOTES FOR MISSOURI FOR THE SEASON OF 1908

By Mary E. Murtfeldt, *Kirkwood, Mo.*

Throughout Central Missouri and in many other sections of the Mississippi Valley somewhat unusual weather conditions have prevailed for the past two years and it has been interesting to note the effect upon the disappearance or prevalence of injurious insects.

In 1907, from the 15th to the end of March, July heats and showers

were followed by very low temperatures and sleet and snow storms over a large part of the Middle West. In consequence of this, almost the entire tree fruit crop was destroyed. Here and there in peculiar situations a few peaches and apples matured, but in the vicinity of St. Louis there was such a dearth of the larger fruits that very few codling moth or curculio larvæ were able to find sustenance, and orchardists were to some extent comforted for the loss of their crops by the assurance that not enough of the principal pests of the more important fruits could possibly survive to do appreciable injury the following year.

But nature has many resources for man's discomfiture. True, codling moth larvæ and curculios, as predicted, were scarcely to be seen, and the winter had been favorable for the preservation of the fruit buds, but scarcely had the blossoms begun to unfold when an overwhelming outbreak of *Aphididæ* occurred. *Aphis mali* on apple and quince, *A. prunifolii* on the plum, *Myzus persicæ* on the peach, in such numbers that the blossoms were dwarfed and tarnished and the young leaves so distorted and crumpled that the trees had the appearance of being blighted. Comparatively little fruit set, even on trees that were sprayed, and very few or no perfect fruits developed on apple, pear or quince trees. The scanty crop of peaches—reduced chiefly through the extensive injury to the foliage—was of better quality than that of the pip fruits, and this was also the case with such of the cherries and plums as escaped the brown-rot.

In the vegetable garden also, the same class of insects rendered young plants of cabbage, mustard, lettuce, and later melons and cucumbers, objects of abhorrence with the piled-up myriads of sap suckers clustered on leaf and stem and blossom. In the flower garden scarce a shrub, herbaceous, perennial or annual, afforded any satisfactory blossoming or luxuriant growth throughout the season on account of the extraction of its vital juices by aphids, green and yellow, brown and red.

This would not have been the case had not almost constant and torrential rains prevailed throughout May and June, undoubtedly drowning out the natural enemies and checks of these pests. It was not until the middle of July or later that I began to note on the clusters of aphids some Coccinellid, Syrphus and Chrysopa larvæ and during the succeeding late summer and autumn drought these multiplied and proportionately aphids diminished. *Aphidius* and *Aphelinus* species did not become at all numerous, to judge by the comparatively few parasited specimens observed.

At present (December 20) very few aphid or winter eggs are to

be found even on the most profusely infested trees and plants, and fruit growers and gardeners are hoping that the scourge has run its course for the present.

[This concludes the list of papers read by title.]

NOTES ON INSECTS AFFECTING THE COCOANUT TREES IN THE SOCIETY ISLANDS

By R. W. Doane, *Stanford University, Cal.*

In a previous issue of this Journal, 1: 341, I have given a few notes on *Aspidiotus destructor* and its work on the cocoanut trees in these islands. While this insect is responsible for the greatest injury to the trees, there are several others that are of more or less importance. Among the scale insects *Hemichionaspis aspidistræ* ranks next to *A. destructor* in numbers and probably in amount of damage done. The two are usually found together on the leaves and fruits. *H. aspidistrae* occurs on all parts (except the trunk and roots) of both the old and young trees, the white scales of the males often forming white patches that nearly or quite cover the leaflets on many of the leaves. But it is on the nuts that it is most abundant and most conspicuous. The husk of both the young and the old nuts are often almost completely covered with it. On account of this habit of attacking the husks of the nuts it is not as injurious as it would be if it confined its attention to the young tender leaves. I also collected it and had it sent to me from several of the islands of the group on a number of unidentified weeds and shrubs. Everywhere it is abundantly parasitized by a small chalcid, but I did not succeed in rearing the parasite. *Lepidosaphes gloveri* is often very abundant on the bases of the older leaves, but as long as its attacks are restricted to this part of the tree the damage done is not very great. It is everywhere badly parasitized. On some leaves practically all of the scales showed the small round hole where the parasite had escaped. On the young tender unfolding leaves of many of the trees, both old and young, are to be found large colonies of *Pseudococcus pandani*. Some of the young trees are seriously injured in this way, for as fast as the tender leaves break from their sheath the insects attack them and when abundant produce a considerable amount of honey dew. This mixed with the white flocculent excretion collects in large drops and masses in the folds of the leaves around and below the colony. No

natural enemies of these insects were observed, but the fact that they are only to be found on protected parts of the tree would indicate that some predaceous form keeps them from spreading to more exposed parts. It is possible that the small skinks and geckos that are so abundant on many of the trees snap up any of the insects that are accessible. What seems to be the same species of mealy-bug occurs abundantly on the *Pandanus*. These are often in somewhat more exposed places and I have seen the larvæ of lacewing flies feeding on them. It is very likely that these larvæ attack the mealy-bug on the cocoanut trees as well. This is probably the same species of *Pseudococcus* that is reported as doing considerable damage to cocoanut trees in other groups of the South Sea Islands.

Toward the base of many of the older leaves on some of the trees may be seen small holes, from which flows a resin-like exudation. Often this has issued to such an extent that the whole lower portion of the leaf is covered, or it collects in lumps on the leaf below. Often bits of leaf-fiber and larval castings are mixed with the exudation. Around these holes the tissue of the leaf is more or less blackened and decayed. Two different types of these holes may be found, usually on the same tree, distinguishable principally by their size and the amount and extent of the injury. Both are made by the larvæ of weevils; a large one, the adult of which is about 13 mm. in length, and a smaller one about one half the size, kindly identified by Mr. Schwarz, through Doctor Howard, as *Sphenophorus obscurus* Boisd. and *Calandra taitensis* Guérin. The larger larva usually works closer to the base of the leaf, often killing the leaf by burrowing all through it. Sometimes the larva will keep close to the edge of the leaf or go only as far in as the center, boring a tortuous chamber from ½ to ¾ an inch in diameter. The burrow is usually filled with the chaff and castings and the larva is usually found at the upper end of the burrow. Often from the blackened portion of the infested leaf the resinous exudation will be issuing in several places, making it appear that several larvæ are at work in the same leaf. This is sometimes the case, but a single larva may bore along a leaf stem for 12 to 15 inches, causing the exudation to flow in abundance from several openings and making many large discolored spots, beneath which the tissue is soft and decayed. The older leaves are usually attacked. After attaining its full growth the larva bores close to the surface and constructs a rude oval cocoon out of the fiber that it has been eating and transforms to the pupa stage, from which it later issues as the adult beetle. These cocoons may usually be found quite abundantly in the chaff at the base of old leaves or in the old leaves. In some in-

stances the larva bores into the trunk of the tree for a short distance where the broad leaf-base joins the tree. In one instance I found the beetle quite abundant in and around the growing tip of a young tree that was dying, whether as a result of the work of the beetle or from some other cause I was unable to determine.

The smaller weevil, *C. taitensis,* seems to be much more abundant and on account of its habits is perhaps more injurious than the larger species. It is found most commonly boring into the edge of the base of the leaf-stem. Its presence is indicated, as with the larger species, by the presence of a gummy exudation mixed with castings. These are often in the shape of long twisted strings, ¼ to ½ inch long. As the larvæ do not work as deep in the tissue of the leaf as do those of the larger species, the damage here is not very great, but when they work further out at the base of the leaflets many of the leaflets are destroyed.

A still more serious damage is done where the larvæ attack the spikelets, killing them at the point of attack and working toward the base. As long as they confine their work to the portion of the spike having only the male flowers the damage is not serious, because the number of these flowers is so great. But when they attack the spikelet below the female or fruiting flower, the young fruit is killed. After the larva has become full grown it makes for itself a rather long cell, with a very thin wall on one side, and, without making a cocoon changes to the pupa, from which, later, the adult emerges and break through the thin wall of its cell.

Another insect that is doing much damage to many of the cocoanut trees on all parts of these islands is the larva of a small moth that works on the underside of the leaflets, eating away the lower surface and causing the whole leaflet to turn brown and die. Often large portion of the leaf is thus destroyed, giving the whole tree very ragged appearance and of course doing considerable damage when many leaves are affected. The larva spins a thin, protective net of silk as it feeds. Along the midrib or at the base of the leaflet a denser web is formed, to which the larva, by a peculiar jerky motion retreats when disturbed. A very few pupæ were taken, but I was not able to rear the adult moth, so I cannot identify the species.

There is another small moth larva that may prove to be of considerable importance on account of its habit of attacking the male flower buds as soon as they are exposed by the opening of the spathe. Many of the spikelets are nearly or quite stripped of their buds before the flower opens. The larva works just at the base of the bud, usually inside, often extending its work out along the stem for a short dis-

tree, and sometimes boring into the spikelet. In some instances the web may connect two or three near-by buds, the larva resting between or in one of them. The larvæ when disturbed or driven from their retreat move along the spikelet with a quick, jerky motion. No adults were reared, so I do not know the species.

On some of the trees, where male spikelets were in bloom, the spike would be literally covered with two species of Oedemerids, *Ananca livida* Fab. (Oliv.), and *A. collaris* Sharp (also identified by Mr. Schwarz), the former being more abundant. They were feeding on the pollen and where a spike was badly attacked practically all the pollen was destroyed. This might prove to be of some importance if many trees were attacked. Mr. Schwarz points out that the members of the closely related American genus *Oxacis* breed in rotten wood and that the imagoes of some of the Florida species congregate on the flowers of palm trees. A thorough study of the insect enemies of the cocoanut trees in this region would doubtless result in a considerable saving to the planters.

RECENT WORK IN INSECT BEHAVIOR AND ITS ECONOMIC SIGNIFICANCE[1]

By William B. Herms, *Assistant Professor in Entomology, University of California*

Animal behavior has been the subject of much investigation during the past ten years, with the purpose of analyzing the organism's method of orientation to a stimulus and the method of locomotion toward or away from such a source of stimulation. Paper after paper has been published, affording considerable information on the subject,—the "tropism" scheme, the "trial and error" method, and the "random movement" method have been advanced and criticised, internal factors and external factors have been considered, sundry methods of experimentation have been applied,—but little has been done with an economic aim. Certainly a narrow viewpoint would be evident were we to expect an immediate economic return for every new effort in science; it must be considered that many if not all applied sciences have found their origin in pure science, and a heedless attitude toward the same may result in actual hindrance to progress. But the agriculturist who has to deal at first hand with the pests of the orchards and of the field may well ask the question of the student of animal

[1] A paper presented at the Watsonville (California) Entomological Conference, Aug. 25, 1908.

behavior, "Can your science lend us aid in the warfare against our enemies?" None present this afternoon will doubt for an instant the commercial importance of such biological sciences as zoölogy, entomology and botany, even at this time when the economic department of these subjects is still in its infancy, and it is safe to say that the next few years will prove the same for the science under consideration.

It is my purpose in this paper to first point out the scope of "Animal Behavior" as accepted by the more progressive group of workers in this field led by such investigators as Parker, Jennings *et al* on the one hand, and Yerkes, Watson *et al* on the other. As just indicated, it should be understood that there are really two more or less distinct groups of workers in the science of animal behavior: the one concerned mainly with the external factors—the comparative physiologists; and the other group concerned mainly with the internal factors—the comparative psychologists.

In the second place I wish to point out some of the more recent work in *insect* behavior, treating this phase from a more or less critical standpoint.

I Scope of Animal Behavior

The behavior of anything, whether organic or inorganic, rests upon activity; the activity of *living* things is determined by the interaction of two classes of determining factors, viz.:

1. Quality of the protoplasm=internal.
2. Quality of the environment=external.

By any change of the external agencies that act upon the organism, the latter is stimulated, because irritability is a characteristic of protoplasm. Therefore a *stimulus* may be defined as any change of the external agencies which act upon the organism, *e. g.*, alteration of temperature, moisture, amount of food, etc.,—in short, the addition of a new factor, or the increase or decrease in degree of an old factor. *Stimulation* is the result of contact of a stimulus upon the living substance, and the fact of stimulation is made obvious by movement or by a reaction of some kind. Stimuli may vary enormously in extent as thermal and chemical stimuli, but the limits within which these conditions act as a stimulus are very narrow, and the total range of a stimulus has not equal importance. The animal lives better near normal conditions than near either extreme. Every organism is adapted so that it will live best at a certain degree of stimulation, *i. e.*, optimal—at the minimal or maximal death ensues.

The reaction of an animal is carried out through the inter-relation

between the sense organs (receptors), the central nervous system and the muscles or glands (effectors). Among the most intangible phenomena that we have to deal with are sensations, yet the old classification of sense organs is based on such internal conditions, and consequently the usual classification, that of sight, smell, touch, hearing and taste is quite unsatisfactory. Because of the inadequacy of the subjective basis for classification, the tendency is to transfer the treatment to an objective basis.[1] The external world forms a basis for the source of stimuli or energy change. On this basis sense organs are grouped into only two general classes, viz.: 1. Sense organs stimulated by ether changes, such as light, heat and electricity. 2. Sense organs stimulated by material changes, sub-divided into two subclasses: *(a)* Physical, organs which receive prolonged contact stimulation, such as touch and pressure, and organs which receive vibratory contact, commonly called sound organs (hearing); *(b)* Chemical, organs which serve as receptors of chemical stimuli, taste and smell.

Thus the weight is thrown on the external world, we are not limited to sensations, and, what is most important, a basis for measurement may be secured,—*e. g.*, light intensity can be measured in terms of candle meters and can be controlled; chemical solutions can be measured in degrees of concentration and can be controlled. And here is where the great difference exists between earlier and more recent work in animal behavior. Accuracy of measurement is the great criterion by which modern work is judged, and this involves not only a knowledge of zoölogy or entomology and their histological methods, but also a knowledge of the physics and chemistry of the stimulus employed. The following extract taken from the editorial notes of a recent number of the Experiment Station Record[2] is quite apropos at this time:

"The advantage of agricultural science over the individual sciences as applied to agricultural problems should lie in its special point of view and in the bringing of various sciences to bear on these problems. For its purposes the boundaries of the primary sciences are overstepped. The investigator in that field is not restricted to a single science, but employs the teachings and the methods of several, as his case requires, acting as a connecting or coördinating agent. This cosmopolitan relationship calls for widespread familiarity with the whole field of natural science. Its danger is too close specialization and disregard of everything in the pure sciences which does not bear directly and quite immediately on the field of agriculture. Such a course tends to narrowness and to superficiality on the part of its adherents."

2 Recent Work in Insect Behavior

As numerous as this group of animals is, comparatively little has been done on them by workers classed as students of animal behavior, and furthermore that which has been accomplished has been directed largely toward species of relatively little economic importance. The pomace fly (*Drosophila ampelophila*) has received much attention in the Harvard zoölogical laboratories, chiefly because of its availability during the winter months, since it is easily reared in artificially heated rooms. Carpenter[3] has made a study of the reactions of this fly to light, gravity and mechanical stimulation. The fly moves toward a source of light, *i. e.*, light has a directive effect, but this is not apparent until a sufficiently powerful kinetic stimulus (light or mechanical) has been exerted to induce locomotion. When very high intensities are used, *e. g.*, a 250 c. p. arc light, at 40 cm., the directive effect of the light is apparently inhibited. Continued exposure to direct sunlight caused many insects to come to rest in the least brightly illuminated regions and with the heads away from the source of light. This last fact is explained because this is the position in which the least light enters the eyes, and in which, as a consequence, the kinetic stimulus is least. The great number of these flies around cider presses, orchards and packing houses where fermenting fruit is often found in quantities, leads one to wonder how these creatures find these localities. It is, of course, a well known fact that these flies deposit their eggs in fermenting fruit, and that the larvæ or maggots feed and develop in such matter. The most natural inference (because these insects bear conspicuous compound eyes) is that the food is located by means of the sense of sight, but as a matter of fact "they find their food with great certainty even in the dark." This led Barrows[4] to take up an investigation of their reactions to "odorous substances." The flies were tested by accurate methods to various intensities of substances commonly found in fermenting fruit, such as ethyl alcohol, acetic and lactic acid, and acetic ether, each used separately and also mixtures of them. The intensity of concentration was known in each, an important consideration in such work. It was found that the optimum strength of ethyl alcohol and acetic acid is 20 and 5 per cent respectively. It was further ascertained that cider vinegar, fermented cider and California sherry contain alcohol and acetic acid in percents very close to the optimum strength. By experiment it was next determined that the sense of smell by means of which food is found, is located in the terminal segment of the fly's antenna.

The eyes of insects have long been studied for their structure and physiology and one of the most important studies recently made on the image-forming powers of eyes was carried on by Cole.[5] This investigator experimented on *Vanessa antiopa* (the mourning cloak butterfly), *Ranatra* (the water scorpion), *Tenebrio* (the meal worm), and again the pomace fly, also several other animals. This work, though not conclusive for some of the species studied, provides conclusive evidence that at least the mourning cloak butterfly and the water scorpion of the animals possessing compound eyes have image-forming powers. This evidence is further augmented by recent experiments by the writer[6] on two common species of flesh-flies, *Lucilia cæsar*, and *Calliphora vomitoria*, with the further evidence that the eyes of these flies have this power not so well developed as the butterfly, which is probably correlated with differences in habit, the flesh-flies being more dependent on their sense of smell. Parker[7] in his investigation of the light reactions of the mourning cloak butterfly, discovered that it reacts to bright patches of sunlight. The larvæ of *Corethra plumicornis*, a short-beaked mosquito, have received the attention of various investigators, among them Harper,[8] who has investigated experimentally their daily depth migration. Ants have formed the basis of a number of classical works represented by Lubbock, Forel and Wasmann, and still these interesting creatures receive the attention of many recent investigators with results fully as significant, due to the application of new and more accurate experimental methods. Much of this work has however taken the form of comparative psychology, as has the splendid work of Turner.[9] The investigations of Fielde,[10] and Fielde and Parker,[11] have afforded us much information on the sensory reactions of these organisms.

The above references have been made to afford some idea of the nature of the work carried on by students of animal behavior, and it will be seen that that which concerns the economic worker most is the experimental method applied, since the species studied have little or no significance from the economic standpoint. But it is this experimental method, carrying with it utmost accuracy, that may well concern us who are interested in the control of insect pests. What is most needed at this time in the study of economic species,—granting the importance of a knowledge of life histories,—is a knowledge of its reaction to a given stimulus (the optimum stimulus) not only at one period of its life history but throughout every active period, because the reaction of an animal at one stage may not be its reaction at another, *e. g.*, the flesh-fly, *Lucilia cæsar*. Though others supposed its reactions to light to be of a rather simple nature, which is

largely true for a given period, its reactions throughout the life history of the individual show progressive change, viz.: first, during the feeding period the larvæ as a body react positively to artificial light, though as individuals they are apparently always strongly negative; secondly, the migrated larvæ (in the pre-pupal period) are uniformly negative; and finally, though the larvæ pupate as negative organisms, they emerge in a positive state. (In this connection one should consider the fact that the larvæ are eyeless creatures, while the adults possess well developed compound eyes.) The following table shows this range of reaction of *individuals* to a given stimulus, light of 0.56 C. M. intensity.

TABLE 1

Summary of reactions of Lucilia cæsar (Lot No. 10) at different ages to directive light (0.56 C. M.). Based on ten larvæ given five trials each to an exposure of thirty seconds.

REACTION

DATE—1907.	AGE.	STAGE.	TRIALS.			PERCENTAGE.		
Dec. 5, a. m.	Birth.	Just hatched.	a 8 b 1	5 11	7 8	a 40 b 5	25 55	35 40
" 6, 10:45 a. m.	24 hours,	Feeding.	6	31	13	12	62	26
" 7, 10:35 "	48 "	"	3	36	11	6	72	22
" 8, 10:35 "	72 "	"	1	42	7	2	84	14
" 9, 10:45 "	96 "	"	0	44	6	0	88	12
" 10, 10:35 "	110 "	"	0	47	3	0	94	6
" 11, 10:35 "	6 days.	Prepupal.	1	47	2	2	94	4
" 12, 10:40 "	7 "	"	2	48	0	4	96	0
" 13, 10:35 "	8 "	"	0	50	0	0	100	0
" 14, 10:30 "	9 "	"	3	46	1	6	92	2
" 16, 10:30 "	11 "	"	2	28	0	7	93	0
" 17, 10:30 "	12 "	"	0	20	0	0	100	0
" 18, 10:30 "	13 "	"	0	10	0	0	100	0
" 26–30.	25 "	Imago.	27[1]	1	0	97	3	0

A further question which must be carefully considered is, Does the behavior of the organism vary with the intensity of the stimulus and what is the variation? This is again illustrated by another table (Table 2), which shows the reactiveness to directive light for various intensities of two species of flesh flies. Here is also illustrated the difference in reactiveness of two related species to exactly the same

[1] This aberrant reaction was on the part of an individual whose wings did not spread and was consequently forced to creep. All other adults first perched on the edge of the vial in which they were retained and then flew toward the light.

intensity of stimulation, *i. e.*, an examination of the following table reveals the fact that *Lucilia cæsar* is a fly which is more reactive to light in the larval stage than is *Calliphora vomitoria*, which was also experimentally shown for the adults.

TABLE 2

Reactiveness to directive light through the general range of intensity for migrated larvæ of Lucilia cæsar (Lots No. 6 (A) and No. 25 B), and of Calliphora vomitoria, (Lot No. 24.)[1]

REACTIONS

Source of Light.	Intensity in C. M.	*L. cæsar.*				*C. vomitoria.*		
			P.	*N.*	*I.*	*P.*	*N.*	*I.*
Diffuse daylight.	?	(A)	0	50	0	0	50	0
Arc light.	800.	(A)	0	50	0	0	47	3
Incandescent light.	0.56	(A)	1	44	5	3	44	3
" "	0.1764	(A)	5	37	8	8	32	10
" "	0.0342	(A)	6	35	8	2	35	13
" "	0.00705	(B)	0	33	18	7	24	19
" "	0.00176	(B)	2	28	20	8	17	25
" "	0.00063	(B)	5	14	28	9	11	30
" "	0.00007	(A)	1	3	46	5	4	41
....	Total darkness.	(A)	2	2	46	5	1	44

It should be explained that the study of the flesh-flies was undertaken by the writer [12] because of their importance as scavengers of lake beach debris, and were used later as favorable organisms for detailed observation with regard to light reactions.[6]

In conclusion I cannot refrain from expressing my regret that there are students of animal behavior who know only the laboratory aspect of animals, who seem to believe that it is unbecoming to carry on field observations. Plucking an animal from its native soil without a thought of its natural environment and hustling it into the laboratory and subjecting it there to all manner of stimuli, often of unknown intensity and quality, is certainly not a commendable method of procedure. The normal environment and normal behavior of an organism should have the experimentor's closest attention, in order to aid in a correct interpretation of the phenomena observed under experimental conditions. A combination of field and laboratory

[1] The reactions (P. N. I. = positive, negative and indifferent respectively) are based on the movements of ten larvæ given five trials each at an exposure of thirty seconds. Between trials, taking larvæ No. 1 first, then No. 2, etc., through the series, each individual was kept separate in a closed receptacle.